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Remote Sensing Enabled Urban Growth Analysis for Gurgaon from 1995 To 2015

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Abstract

Now a days' Guragaon District of Haryana is becoming the hub of the multinational companies and becoming the glaring example of rapid urban growth. Due to rapid and population explosion, the pressure on vital ecosystem has also increased drastically. Industrialization and urbanization have changed the natural landscape and socio-economic profiles of Gurgaon. For responding to a phenomenon like urban sprawl, a proper quantification of urban sprawl in integration with parameters like population is required. In this study urbanization of Gurgaon has been extracted using satellite remote sensing data. Normalized Index based method (NDBI) is used to compute the results which are further plotted with population's statistics to understand the immediate reasons of urban growth. This work will definitely be helpful to landuse planners and decision makers to take better decision to mitigate the effect of growing population.

Keywords: Remote Sensing, Urban Sprawl, Population, Gurgaon, NDBI.

1. INTRODUCTION

Monitoring and mapping of urban growth requires robust techniques. Remote sensing (RS) data illustrates spatial location of various activities and analyzing the linkages between activities, regional plan, development plan and environmental plans are prepared. Remote sensing helps in creating relationship between different aspects of urban growth whereas GIS helps in providing information that can be processed as per the requirement of future planning (Tiwari et al., 2014). The advantage of Remote Sensing data includes reliability and cost effectiveness of data with area and location information. Further, with remote sensing data, it is to extract land cover information to prepare base map. It helps in planning, monitoring and implementation strategies due to the availability of time series data (Gonzalez and Woods 2007).

Urban sprawl is a dynamic process and relationship between urban sprawl and factors responsible for urban sprawl, is one of the primary objective in the urban research agenda. Since, future urban expansion and managing urban services require exhaustive data for better understanding the ongoing growth processes and development patterns by resources persons, managers and research scientist.

Data availability through remote sensing technology is one of the prime concerns. Moreover, issues related to spatial and spectral heterogeneity of urban environment are also taken into consideration while selection of satellite imagery (Jensen and cowen, 1999; Herold et al., 2004). Urban related application needs an appropriate source of image data to support such studies. It is unquestionable that the earth observation is a modern science and through satellite data, earth changing environment can be studied in an efficient way (Ramachandra and Bharath 2012).

It is believed that for analysis of urban sprawl, remote sensing technology may provide an exclusive outlook on urban growth and LULC change process Batty and Howes (2001). Consistency in obtaining satellite data through remote sensing over time helps in providing useful LULC information at different geographical scales. The information derived using remotely sensed satellite imagery may help to recognize the modeling aspect of urban environment that leads to an improved and thoughtful understanding of various factors responsible for urban growth and its consequences (Banister et al., 1997).

Landuse Land cover change detection is very helpful tool to understand the pattern of urban growth. And this change detection analysis can only be possible the with help of satellite data of different time period. Different observation such as spatial and temporal disparity in growth and whether the growth is sprawling or not, may be studied as an outcome of such analysis.

In order to recognize urban pattern, remote sensing along with GIS has been used in very efficient way. Moreover, to monitor sprawl and model the urban growth these two are extensively used due to their time and cost effectiveness. Moreover, by using GIS functionalities like decision support systems may evaluate the remote sensing outcome in conjunction with other geospatial database (Tiwari and Jain, 2014). Hence, suitability analysis, future prediction and other related studies have become possible in less amount of time.

Herold et al. (2004), directed an inclusive research on dynamics of urban growth pattern with the help of remotely sensed images, for accumulation of landscape metrics that has been finally evaluated and inferred in aggregation with outcomes obtained from spatial urban growth modeling. The study carried out by them revealed that technology that combining geospatial techniques, landscape metrics, along with modeling of urban growth have been an encouraging approach to analyze spatiotemporal behavior of urbanization.

According to Sudhira et. al. (2004), main reasons for urban sprawl have been population and economic growth. Their work has been carried out for Manglore, India covering the duration, 1972 to 1999. Their studies show that there is a growth in population to an extent of 55%. However, for the same duration, the increment is observed in built-up area is 145%. By using remote sensing and GIS techniques, they identify dominantly unplanned expansion and propagation of densely built-up zones.

Observed land cover change over time, reveals the effects and impacts of urbanization in peri-urban areas. Their work investigates the spatial pattern of land conversion in the Tapiei-Taoyuan area by interpreting 1990 and 2006 SPOT images. Landscape metrics were used to analyze the spatial and temporal changes of landscape patterns of peri-urbanization. Accordingly, it was found that the urban sprawl in non-urban planned districts is more severe than in urban planned districts and that the non-urban planned districts is highly fragmented.

Emphasized on using quantitative techniques which is turn help to better identify and address local, regional and state land use change. To identify the urban growth types, geographical information system and remote sensing technology were used to understand the long term trends and pattern of urban growth the spatial metrics were used.

Abebe G.A. (2013) observed that the spatio-temporal patterns and processes of urban growth of Kampala between 1989 and 2010 were investigated to evaluate the dynamic of urban growth. To evaluate and analysis of spatial metrics the satellite remote sensing images, spatial metrics and logistics regression modeling was used.

STUDY AREA

The study area of urban growth analysis between 1995 and 2015 has been restricted to Gurgaon district of Haryana state. The district lies in latitudes between 27º39´N and

28º32´N and in longitudes 76º39´ and 77º20´ E. The district in covering an area of 125 sq. Km. The study area has four tehsils, viz. Pataudi, Gurgaon, Nuls and Ferozepur Jhirka. The location of the district is shown in figure1. On its norsth, it is bounded by the Rohtak district & Delhi as shown in map. On its south, there are the U.P. and Rajasthan and to its west lies the Mahendergarh district. The district is just 32km from New Delhi.

The transportation network of Gurgaon district is shown in fig. 2. The map on the roads in Gurgaon makes finding the locations and distance of these places from Gurgaon very easy. Figure 2, represents Road Map of Gurgaon and highlights important roads that connect Gurgaon to its neighboring districts of Faridabad and Rohtak and to the states of Tamil Nadu and Andhra Pradesh.

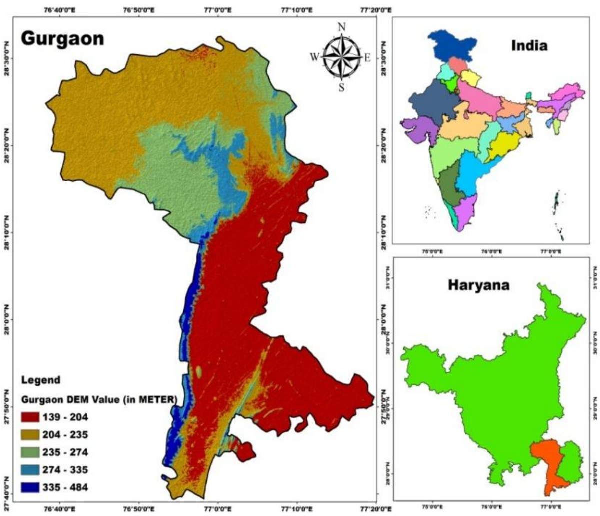


Figure 1: Study Area: Gurgaon

Figure 2. Gurgaon Transportation network

DATA USED

Primary and secondary data were used to perform the above study. The data includes:

a) Landsat-5 TM data (April 1995),
b) Landsat-7 ETM+ data (February 2001),
c) Landsat-5 TM data (October 2008),
d) Landsat-8 OLI image (May 2015)

Table 1 presents the specifications of different Landsat data mentioned above Topographical maps are very important source of information to carry out the geospatial studies as these maps give the basic terrain information. All the maps and satellite images are geo-referenced with the help of topographic maps.

NORMALIZED DIFFERENCE BUILT-UP INDEX (NDBI)

The concept of NDBI in automatically mapping the urban areas from TM imagery was proposed by Zha et al.(2003), NDBI has been recently employed as an indicator to compute the urban built-up areas. This index could differentiate built-up from non-built-up areas. The drastic increment in reflection of built-up area and barren land from band 4 to band 5 has been utilized for making the standard differentiation of these two bands.

$$\text{NDBI} = \frac{\text{SWIR} - \text{NIR}}{\text{SWIR} + \text{NIR}} \quad \text{………..equation 1}$$

The resultant values from this processing show values near to zero for vegetated surfaces, negative values for water bodies and the highest values for built-up areas.

POPULATION EXPLOSION IN GURGAON

Rampant urbanization and industrial growth have resulted in an exponential increase in Gurgaon population in the last 10 years. The growth could have been because of the immigration of people from Delhi due to availability of affordable housing in the city in comparison to the national capital. The dream city of Gurgaon attracts people from all over India as offices of major multinational companies are set up here. Thus a large number of Gurgaon's population is immigratory.

Table 1. Specifications of Landsat TM, ETM+ and OLI data

Satellite	Sensor	Path	Row	Acquisition Date	Time (GMT)	Resolution (m)
Landsat 5	TM	146	41	15-Dec-1995	04:19:37	30/120
		147	140		04:27:06	
		146	41	06-Oct-2008	05:03:39	
		147	40		05:09:12	
Landsat 7	ETM+	146	41	05-Feb-2001	04:59:15	30/60
		147	40		05:05:10	
Landsat 8	OLI/TIRS	146	41	25-May-2015	05:18:24	30/100
		147	40		05:24:05	

Table 2. Salient Characteristics for different Landsat sensors

Instrument	Band	Center Wavelength (m)	Bandwidth (m)	Spatial Resolution (m)
TIRS	10	10.9	0.6	100
TIRS	11	12.0	1.0	100
ETM+	6	11.3	2.0	060
TM	6	11.4	2.0	120

Table 3. Land use land cover distribution in the Study Area.

Year	Built up Area		Overall Accuracy	Kappa coefficient	Population
	Area (sq. Km)	Area (%)			
1995	**45.35**	**01.65**	**90.91%**	**0.761**	**166701**
2001	**127.02**	**04.62**	**81.82%**	**0.731**	**870539**
2008	**265.46**	**09.66**	**87.67%**	**0.859**	**1269212**
2015	**488.394**	**17.77**	**85.00%**	**0.713**	**2064427**

In year 1995 the overall population of Gurgaon was 166701which became 20654427 in the 2015 as shown in table 3. The population became about twelve times in last twenty years. Table 3 also indicate that built-up area was 45.35 in the year 1995 which became 488.394 square km in year 2015 which is about eleven times of the initial ones. The table 3 clearly indicating that the built-up area and the population is growing rapidly in Gurgaon district. This will create environmental problem, non abality of services and amenities and solid waste management problem in the region. This will also cause a depletion of ground water laevel in region.

POPULATION GROWTH RATE

The average annual percent change in the population, resulting from a deficit of births over deaths and the balance of migrants entering and leaving a city. The population growth rate is a factor in determining how great a burden would be imposed on a country by the changing needs of its people for infrastructure, resources, and jobs. An exponent’s formula, similar to the one used on compound growth can be used to estimate the Populations of Humans.

$$P = P_0 \times e^{rt}$$ ……..equation 2

P = Total Population after time “t”

P_0 = Starting Population

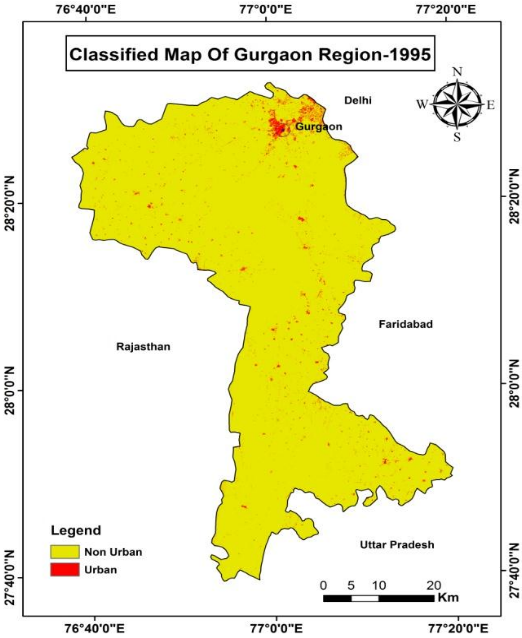
r = % Rate of Growth

T = Time in hours or years

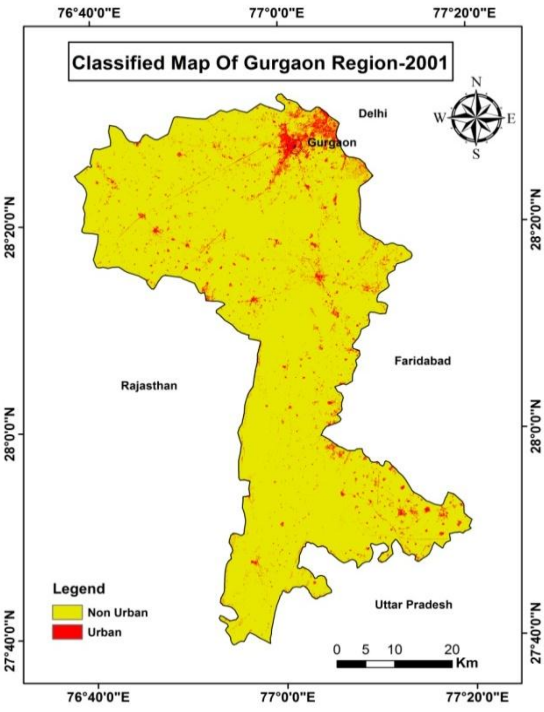
E = Euler number = 2.71828

RESULTS AND DISCUSSION

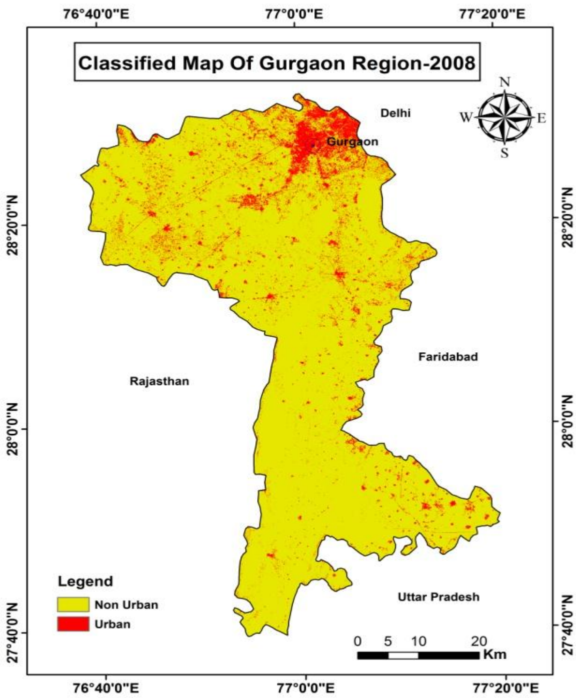
After applying the Normalized Built up Index (NDBI) for satellite imagery from 1995 to 2015, four thematic images is obtained, showing built-up and non built-up classes for the area under investigation (Fig. 3 a, b, c and d). As discussed in Table 3, it is found that built up area was 45.35 sq km (01.65% of total land area) for Gurgaon region in 1995. Built up area was started increasing and reached up to 127.02 sq. km (04.62 % of total area) in 2001. In these 6 years, growth was stable. But in 2008, built up area is 265.46, just doubled of 2001 and 09.66% of total Gurgaon area. The pace of urbanization was started increasing and in 2015, result shows that built up area is 488.394 sq km which is 17.77 % of total area. Thus, it can be concluded from results that urbanization is at its peak in the Gurgaon region. Overall accuracy and Kappa statistics are calculated to show the index performance. For quantitative estimates of the index accuracy of classified images, samples were selected randomly. Table 3 shows overall accuracy and overall Kappa statistics for all four images. It was found that NDBI is extracting built up with the max Kappa value (0. 859) for 2008 and max overall accuracy (90.91%) for 1995.



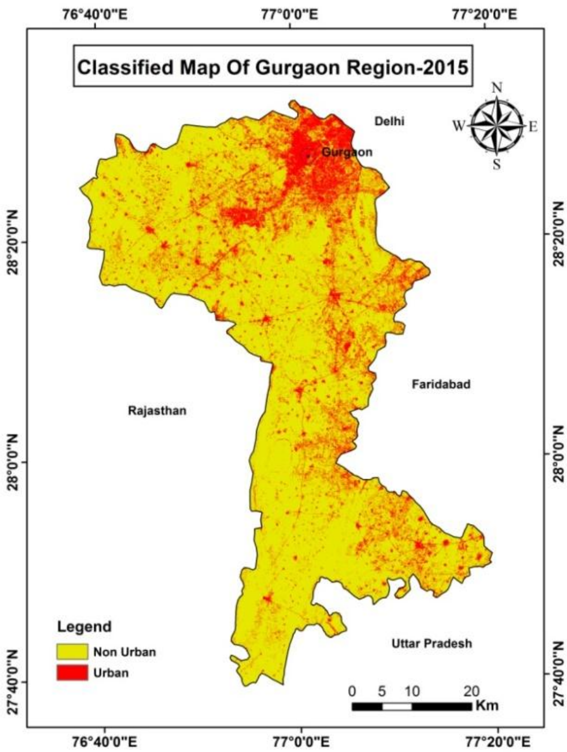
(a)



(b)


76°40'0"E
77°0'0"E
77°20'0"E
Classified Map Of Gurgaon Region-2008
Delhi
Gurgaon
Faridabad
Rajasthan
Uttar Pradesh
28°20'0"N
28°0'0"N
27°40'0"N
Legend
Non Urban
Urban
0 5 10 20
Km

(c)


76°40'0"E
77°0'0"E
77°20'0"E
Classified Map Of Gurgaon Region-2015
Delhi
Gurgaon
Faridabad
Rajasthan
Uttar Pradesh
28°20'0"N
28°0'0"N
27°40'0"N
Legend
Non Urban
Urban
0 5 10 20
Km

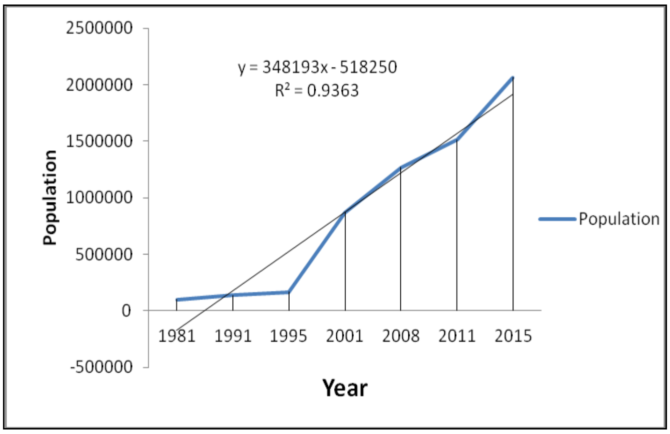
(d)

Figure 3. NDBI based built up area for Gurgaon region for 1995 (a), 2001 (b), 2008 (c) and 2015 (d).

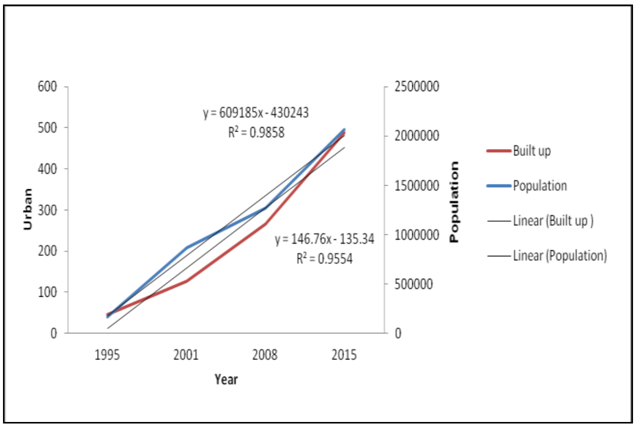
In order to understand the impact of increasing population growth and industry induced migration over built up area. Built up Area and population variation from 1995 to 2015 is shown in Table 4. A graph (Graph 2) is plotted in between Built up area, population and year of study. It is found that there is a highly linear behaviour is shown by both the built up area and population for Gurgaon region from 1995 to 2015. A linear equation is computed for both the built up and population results. Both are showing a strong correlation with 0.98 and 0.95 correlation cofficient values. A correlation graph (Graph 3) between Urban Sprawl and Population Growth from 1995 to 2015 and it is found that both the built up and population has a strong correlation.

Table 4. Built up Area and Population variation from 1995 to 2015.

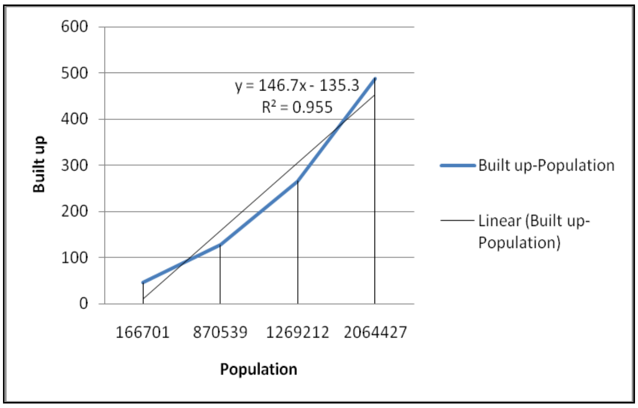
Year	**Built up Area (sq.km)**	**Populatio n**
1995	45.35	166701
2001	127.02	870539
2008	265.46	1269212
2015	488.394	2064427



Graph 1. Population growth of Gurgaon (Source: Census of India, 2011)



Graph 2. Urban Sprawl and Population Growth from 1995 to 2015



Graph 3. Correlation between Urban Sprawl and Population Growth from 1995 to 2015

CONCLUSION

Remote sensing is very helpful for dynamical monitoring of the process of urbanization and drives its reasons when correlated with population data. The intgreated approach of Remote Sensing and GIS technology has demonstrated that how the urbanization, its temporal and spatial distribution and pattern can be quantified and compared. The present study reveals the impact of increasing population growth and industry induced migration over the built-up area. Land sat data proved to be an independent and adequate data source for the analysis of past developing cities of the country. It is observe that the chief driving course to the urbanization is the rapid immigration of population from the neighboring regions. A rapid increase in urban population in Gurgaon urban zones has the great impact on environment of the region.

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